Cache problems

1- Assume you have a cache memory with total size 128 kbytes. Each line will contain a block of 8 bytes. How many lines are there in this cache? Draw a sketch that shows the structure of this cache.

2- If you have a RAM with total size 64 M of words of a byte size. Determine the number of words in this RAM, the address size. Draw a sketch that shows the structure of this RAM.

3- If the two memories (cache and RAM) are used in the same system, determine the number of caches that the RAM can hold.

4- If you are using the direct mapping, how many RAM blocks competing on each cache line?

5- If you are using the associative mapping, how many RAM blocks competing on each cache line?

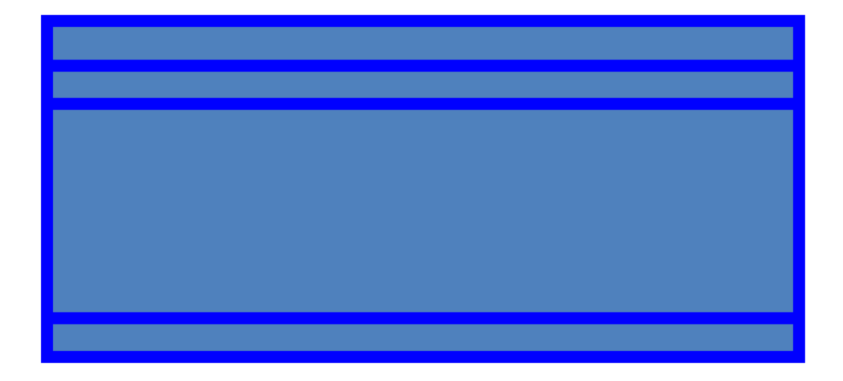
6- If you are using the set associative mapping, with set=4 lines, how many RAM blocks competing on each cache line/set?

7- The replacement algorithm FIFO is used to replace the cache blocks when it is filled. Which cache mapping type is suitable for this algorithm? Describe how it could be applied to our problem.

Solution:

1. Number of lines = total cache size/size of block = 128k/8 = 16k lines

(draw a rectangle with 8 blocks size and length of 16 k,… put beside each line a number starting from 0,1,… till the last one 16k = 16*1024 = 16384 lines)



2- Word size = 1 byte,

Number of words = 64 M/1byte = 64 M words

To get the address $2^n = 64 * 2^{20} = 2^6 * 2^{20} = 2^{26}$ n = 26

Address = 26 bits

(draw a rectangle with 1byte width and length of 64M,… put beside each line a number starting from 0,1,… till the last one 64M, make its length much much larger than the cache length)

3- The RAM will have 8byte blocks , each 16kbytes will constitute a cache.

The number of caches that the RAM can hold = size of RAM/size of Cache = 64M/128K = $2^{26} / 2^{17} (2^7 * 2^{10}) = 2^9$ = 512 cache.

4. If you are using the direct mapping, 512 RAM blocks are competing on each cache line.

5. If you are using the associative mapping, all RAM blocks are competing on each cache line.

6. If you are using the set associative mapping, with set=4 lines, 512 RAM blocks competing on each 4 specific cache lines, or on a set of lines.

7. The replacement algorithm FIFO is used to replace the cache blocks for cache type associative and set associative mapping.

In associative, the block that was brought to cache first (the oldest block) will be replaced with the new block that doesn't find a vacant place in the cache as it is filled.

In set associative, the block that was brought to cache first (the oldest block) within the set lines that the new block is allowed to be put into (4lines) will be replaced with the new block that doesn't find a vacant place in the allowed cache set (4lines) as it is filled.